Instruction Manual

RETURN TO
CALIBRATION LAB.
LOC. A DEPT. 863

MODEL 404 & 404R

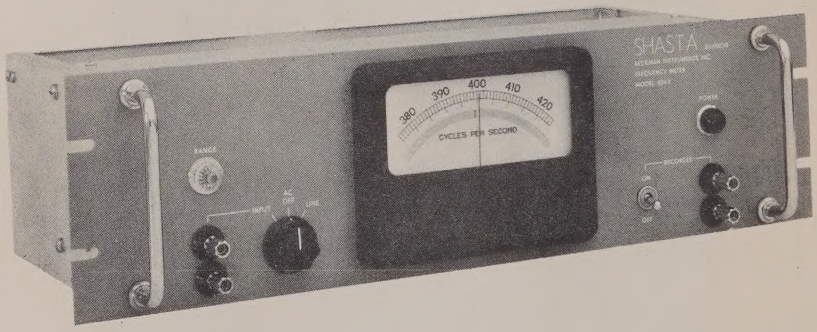
EXPANDED-SCALE FREQUENCY METER

Beckman

Berkeley Division
2200 Wright Avenue, Richmond 3, California
a division of Beckman Instruments, Inc.

RETURN TO
CALIBRATION LAB.
LOC. A DEPT. 863

Model 404


SHASTA
380
390
400
410
420
CYCLES PER SECOND
POWER
RANGE
INPUT
AC
OFF
LINE
RECORDER
ON
OFF

Model 404R

DESCRIPTION

The Model 404 Expanded Scale Frequency Meter is designed for fast, accurate monitoring of frequencies near 400 cps. It was originally intended for use in making production inspection measurements of the frequency regulation of motor and engine-driven generating units, but has found many other applications where a record of frequency is desired.

The Model 404 measures the frequency of the line supplying its power or the frequency of an external signal introduced at a separate input connector. Frequency is indicated on a front panel meter which covers the range from 375 to 425 cps. With this large scale expansion, reading errors due to parallax are insignificant.

A 0 to 1 milliampere recorder may be attached directly to the instrument. The Model 404 has been designed to present critical damping resistance to the Esterline-Angus recorder but other recorders may be used. A current-limiting device is included in the instrument to protect both the recording meter and the panel meter.

The Model 404 is built to be mounted in a standard 19-inch relay rack. It is electrically identical to the Model 404 except that it has INPUT and RECORDER terminals both on the front panel and at the rear.

SPECIFICATIONS

Power Requirements

105 to 125 volts, 50 to 2000 cps, 25 watts.

Input

105 to 125 volts, 375 to 425 cps, 1-1/2 watt.

Accuracy

± 0.5 cps. Error due to harmonics less than 0.5 cps for 5% harmonic content. Error due to voltage change less than .25 cps from 105 to 125 volts.

Recorder Requirements

Current -0.5 to 0 to + 0.5 ma. Recorder resistance 1400 ohms ± 20%. Critical damping resistance 30,000 ohms ± 50%.

Outside Dimensions

8" wide, 10" high, 9" deep.

OPERATION

APPLYING POWER AND CONNECTING INPUT

The meter can be powered in two ways: either by the signal whose frequency is to be measured or by a separate source of line power.

Power Supplied by Signal to be Metered. This is a convenient method of operation whenever the signal source is able to supply 25 watts power. The signal must be 105 to 125 volts rms, 375 to 475 cps. No connection need be made to the front panel INPUT terminals. To place the unit in operation, simply turn the front panel switch to LINE and connect the line power cord to the signal source. The POWER indicator will light, indicating the unit is energized.

Power Supplied by a Separate Source. If the operator does not wish to load the source of the signal being metered, he may draw power from a separate source. The signal to be measured need supply only 1.5 watts at 105 to 125 volts. Connect this signal across the INPUT terminals and place the front panel switch at INPUT. Power may be obtained from any 105 to 125 volt, 50 to 2000 cps source capable of supplying 25 watts. Simply connect the power cord to this source. The POWER indicator will light, indicating that the unit is energized.

Disconnecting Power and Input Signal. When the front panel switch is at AC OFF, both the line power cord and the INPUT terminals are disconnected from all internal circuitry.

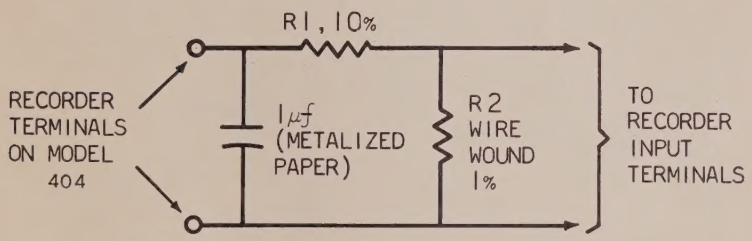
READING THE METER

If no recorder is attached to the frequency meter, place the RECORDER toggle switch at OFF; with a recorder attached, the switch may be at ON. The instrument requires a 5-minute warm-up before it will measure with specified accuracy. If the RANGE indicator does not light, either the frequency being metered is outside the range of 375 to 425 cps or the signal voltage is too low (below 100 volts rms). In either case, the meter indication is meaningless. If the RANGE indicator is lit, the meter will indicate frequency correctly. The reading will be accurate to 0.5 cps provided the signal being measured does not have over 5% harmonic content.

USING A RECORDER

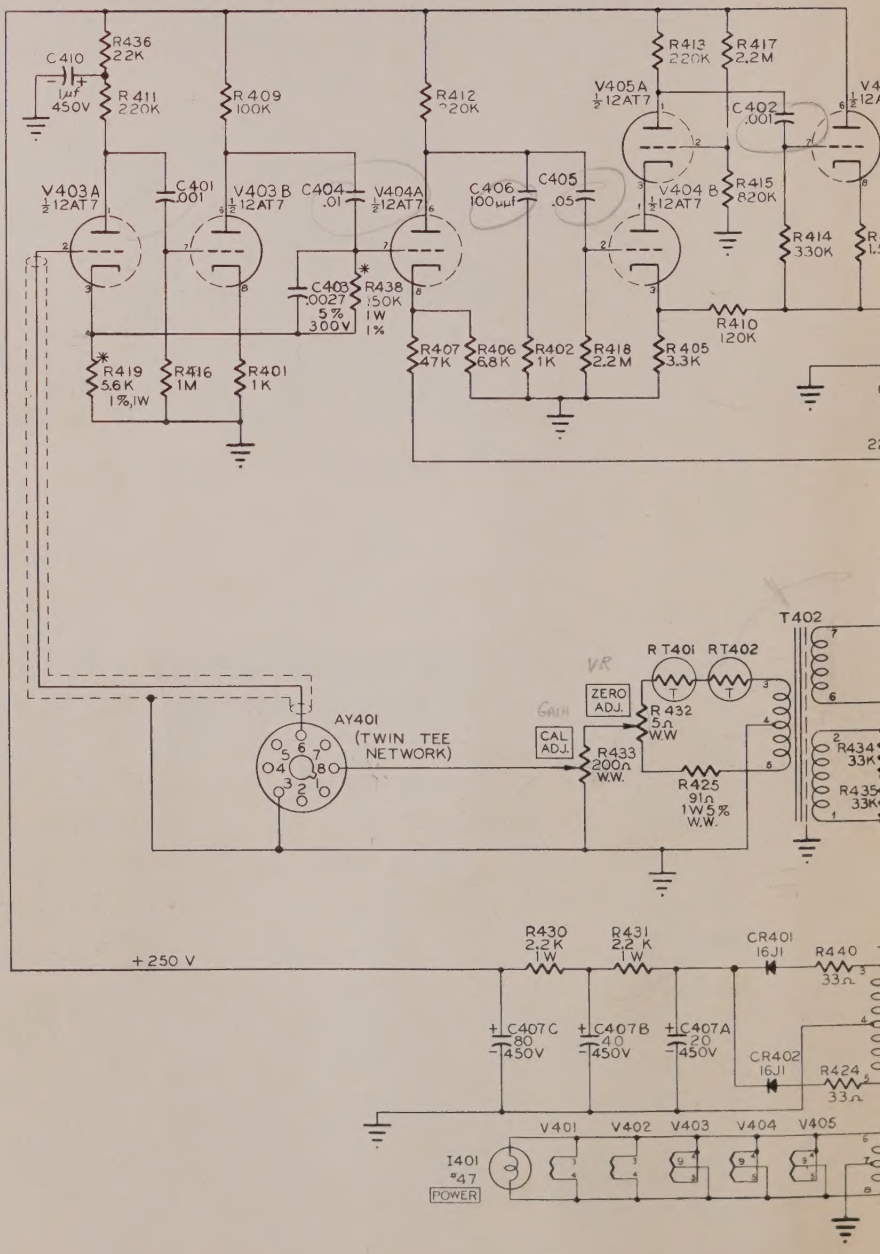
Current Recorders. This instrument is designed to operate with an Esterline-Angus recorder having a full scale range of 0 to 1 ma, an input resistance of 1400 ohms and a critical damping resistance of about 30,000 ohms. Other recorders may be used provided they meet these requirements. To attach a recorder, connect its input terminals to the RECORDER terminals at the rear of the frequency meter and place the adjacent toggle switch at ON. This connects the recorder in series with the front panel milliammeter. Zero current at the recorder terminals corresponds to 400 cps; 0.5 ma in one direction, to 375 cps; and 0.5 ma in the opposite direction, to 425 ma. Consequently, the recorder should be "zeroed" at the center-scale position.

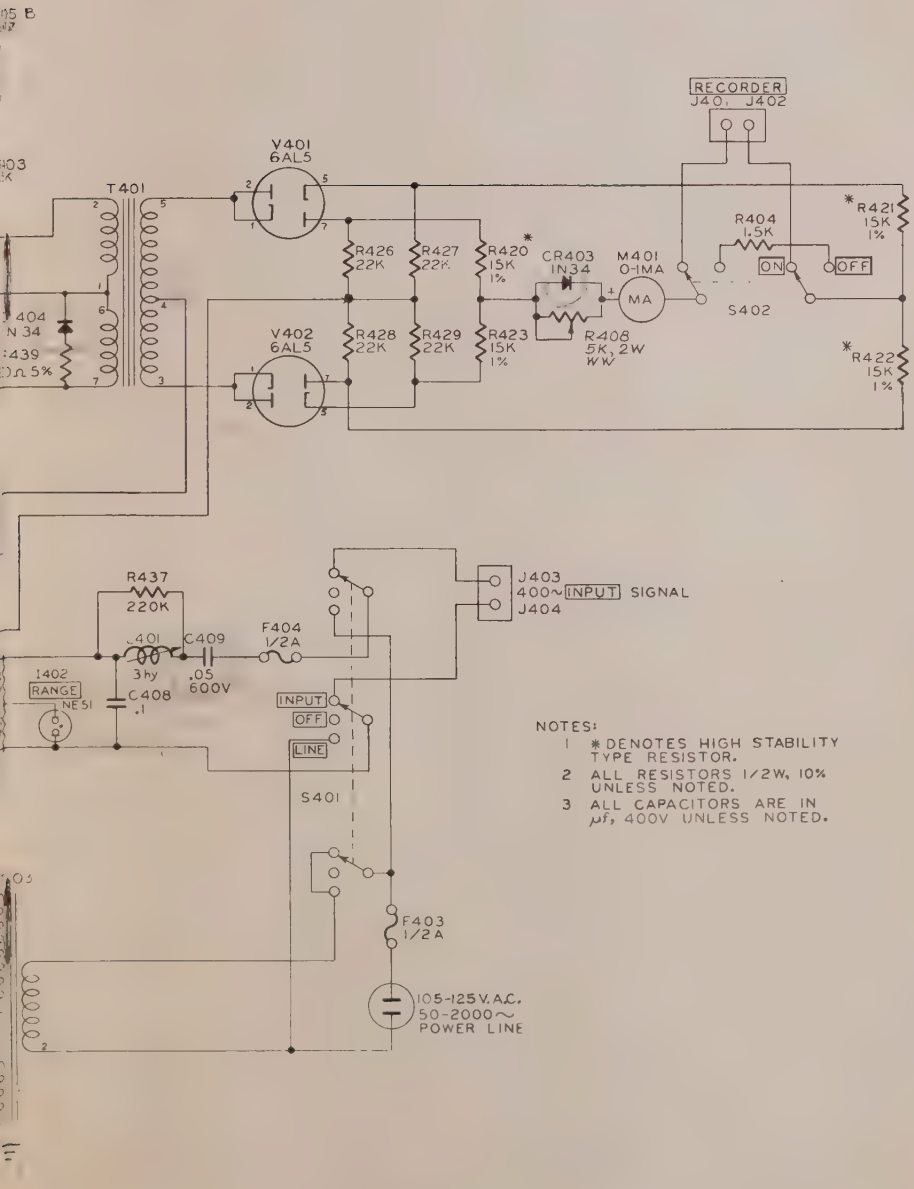
Potentiometeric Recorder. A potentiometeric recorder may be used with the frequency meter if the circuit diagramed below is inserted between the RECORDER terminals on the Model 404 and the recorder input.



R2 should be numerically equal in ohms to the full-scale rating of the recorder stated in millivolts. For example, if full scale on the recorder is 10 mv, R2 should be 10 ohms. R1 should equal 1400 ohms minus R2. Current through R2 will vary linearly from 0.5 ma (in one direction) through zero to 0.5 ma (in the opposite direction) as the frequency being measured varies from 375 cps through 400 cps to 425 cps.

Disconnecting a Recorder. Either type of recorder may be disconnected without impairing the operation of the meter by moving the RECORDER toggle switch to OFF. This places a resistor (approximately 1500 ohms) in series with the meter in place of the 1400-ohm resistance across the RECORDER terminals.


R436 22K
C410 1µf 450V
R411 220K
R409 100K
R412 220K
R413 220K
R417 2.2M
V405A ½12AT7
C402 .001
V404B ½12AT7
R415 820K
R414 330K
V403A ½12AT7
C401 .001
V403B ½12AT7
C404 .01
V404A ½12AT7
C406 100µµf
C405 .05
C403 .0027 5% 300V
R438 150K 1W 1%
R410 120K
R419 5.6K 1%,1W
R416 1M
R401 1K
R407 47K
R406 6.8K
R402 1K
R418 2.2M
R405 3.3K
T402
RT401
RT402
VR
ZERO ADJ.
R432 5Ω W.W
CAL ADJ.
R433 200Ω W.W.
R425 91Ω 1W 5% W.W.
AY401 (TWIN TEE NETWORK)
R430 2.2K 1W
R431 2.2K 1W
CR401 16J1
R440 33Ω
+250 V
+C407C 80 450V
+C407B 40 450V
+C407A 20 450V
CR402 16J1
R424 33Ω
V401
V402
V403
V404
V405
I401 #47 POWER



NOTES:

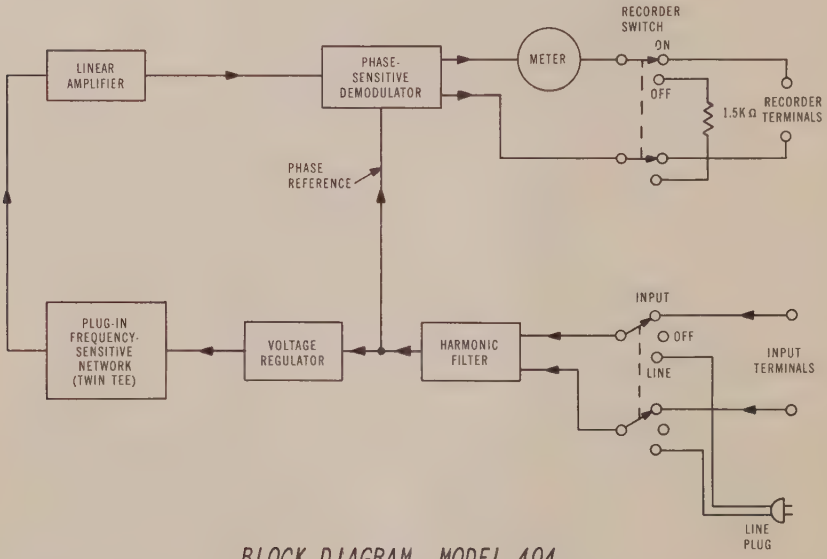
1. * DENOTES HIGH STABILITY TYPE RESISTOR.
2. ALL RESISTORS 1/2W, 10% UNLESS NOTED.
3. ALL CAPACITORS ARE IN μf, 400V UNLESS NOTED.

SCHEMATIC DIAGRAM, MODEL 404

MAINTENANCE

CIRCUIT DESCRIPTION

The block diagram below shows the main functional components of the frequency meter. The signal of the frequency to be measured is first passed through a harmonic filter and a voltage regulating circuit to obtain a pure sinusoidal signal of constant amplitude. This signal is fed to the twin tee network.



BLOCK DIAGRAM, MODEL 404

The twin-tee network senses both the magnitude and the direction of frequency deviation from 400 cps. Its output voltage is proportional to the difference between the input frequency and 400 cps. At 400 cps the output is zero; as the frequency deviates below or above 400 cps, the output voltage rises linearly. The phase of the twin tee output depends upon whether the input frequency is above or below 400 cps. The output when above 400 cps is 180° out of phase with the output when below 400 cps.

The linear amplifier is a combination voltage and power amplifier which contains enough negative feedback to preserve the linear relationship of frequency deviation to voltage created by the twin tee. Phase shift occurring in both the twin tee and the linear amplifier causes the output of the amplifier to be in phase with a reference signal when the frequency is above 400 cps but 180° out of phase with the phase reference when the frequency is below 400 cps. The phase reference is a signal from the output transformer of the harmonic filter. The precise phase reference is the potential at terminal 6 with respect to terminal 7 of T101. (See the schematic diagram.)

The phase-sensitive demodulator puts out a d-c current whose amplitude is proportional to the a-c voltage from the amplifier. The direction of this current is determined by the phase difference between the amplifier output and the phase reference signal. When the amplifier output is zero (that is, when the input frequency is 400 cps) no current flows in the meter and the pointer rests at the center position, indicating 400 cps. When the amplifier output is above zero and 180° out of phase with the reference signal (that is, when the input frequency is below 400 cps) the meter is deflected to the left. When the amplifier output is above zero and in phase with the reference signal (that is, when the input frequency is above 400 cps) current flows through the meter in the opposite direction, deflecting it to the right.

CALIBRATION

The following equipment is required to calibrate the instrument:

1. A signal source, frequency continuously variable from 375 to 425 cps, voltage adjustable from 100 to 130 volts, harmonic content less the 5%.
2. A frequency meter covering range of 375 to 425 cps, accurate to ± 0.1 cps.

To obtain access to the calibration controls, remove the two screws fastening the carrying strap and slip the hood off the chassis in an upward direction. Then proceed as follows:

1. Apply an input frequency of 400 cps and mechanically adjust the panel meter to read 400 cps by rotating screwdriver adjustment on the face of the meter.
2. Apply 425 cps and, while varying the input voltage between 105 and 125 volts, adjust the ZERO ADJ control (R432) for minimum variation in the panel meter reading.
3. Maintaining the 425 cps input, set the CAL ADJ control to cause the meter to read 425.
4. Apply 375 cps and adjust the 375 ADJ control (R408) for a reading of 375.
5. Check panel meter reading at other input frequencies to see that meter reads correctly over the full scale.

COMMON TROUBLES

Symptom. Meter indicates 400 cps at all input frequencies. RANGE indicator lit.

Possible Causes. (1) RECORDER switch at ON with no recorder attached. Move switch to OFF position. (2) Failure of an amplifier tube, V403, V404 or V405.

Symptom. Meter indicates 400 cps at all input frequencies. RANGE indicator not lit. Green indicator lit.

Possible Causes. Fuse F404 blown. Choke L401 or capacitor C408 defective.

Symptom. Meter sensitivity extrodinarily high. Meter reading varies with input voltage over 105 to 125-volt range.

Possible Causes. (1) Voltage-regulating varistor RT401 or RT402 defective. (These components should glow when operating properly). (2) ZERO ADJ potentiometer (R432) defective.

Symptom. Meter indication incorrect at all points except 400 cps.

Possible Cause. Instrument not properly calibrated.

Symptom. Meter indication incorrect at all points on scale.

Possible Cause. (1) Input signal has excessive harmonic content. (2) Precision resistor R421, R422, R423 or R424 not within required 1 % tolerance. (3) Failure of a demodulating tube, V401 or V402.

PARTS LIST

NOTE: The following list includes (other than tubes) only those components not adequately described on the schematic diagram.

TUBES

Type	Quantity	Type	Quantity
6AL5	2	12AT7	3

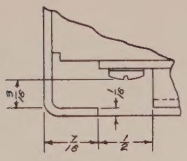
CAPACITORS

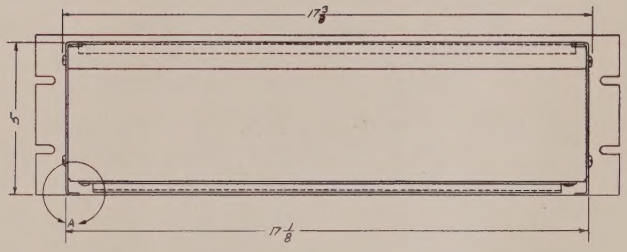
Detail No.	Stock No.	Description
C401 & C402	2-1949	.001 microfarad, 400 V DC Paper
C403	2-6580	.0027 microfarad, 5% Silver Mica
C404	2-5940	.01 microfarad, 400 V DC Paper
C405	2-2150	.05 microfarad, 400 V DC
C406	2-3507	100 microfarad, Ceramicon
C407	2-4159	80 x 40 x 20, 450 V DC
C408	2-3085	.1 microfarad, 400 V DC Paper
C409	2-3662	.05 microfarad, 600V DC
C410	2-2814	1 microfarad 450 V Electrolytic

OTHER COMPONENTS

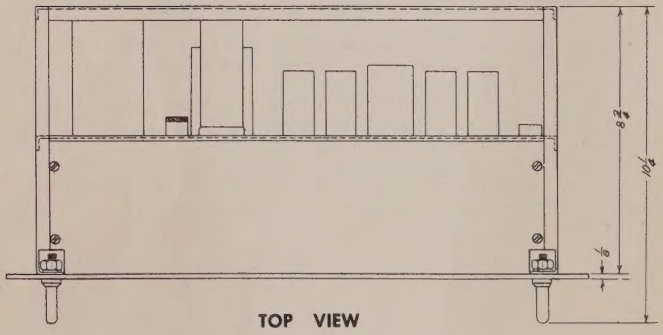
CR401 & CR402	8-5892	Selenium Rectifier
CR403	8-0668	Diode 1N34A
F403 & F404	7-1099	Fuse 1/2 Amp
1401	21-1677	Lamp #47
1402	21-1679	Lamp NE 51
L401	3-6581	Variable Inductor
M401	15-S6571	Meter

R419	1-6583	Resistor 5.6K, 1/2 W, 1% Dep. Carb.
R420, 421 & R422	1-6585	Resistor 15K, 1/2 W, 1% Dep. Carb.
R423		Same as R420
R425	1-4278	Resistor 91 ohms, 5%
R432	1-6578	Potentiometer 3/8 Bushing 3/8 Shaft beyond bushing, Slotted Shaft. 5 ohms, 2 W, WW
R433	1-6579	Potentiometer 200 ohms, 2 W, WW 3/8 Bushing 3/8 Shaft beyond bushing, Slotted Shaft.
R438	1-2834	Resistor 150 K, 1 W, 1% Dep. Carb.
RT401 & RT402	21-4295	Lamp 2 Pin Miniature
T401	6-S6561	Transformer
T402	6-S6563	Transformer
T403	6-S6562	Transformer

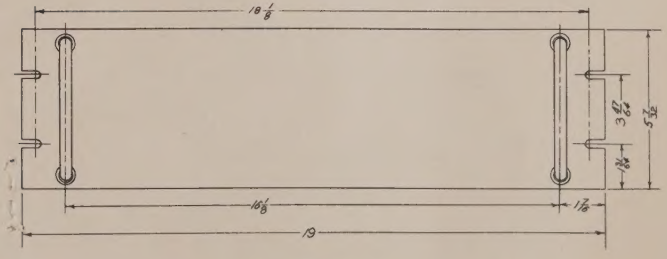




REAR VIEW



TOP VIEW



FRONT VIEW

RACK MOUNTING DIMENSIONS, MODEL 404R

WARRANTY

Every instrument manufactured by the BERKELEY division of Beckman Instruments, Inc. is warranted to be free from defects in material and workmanship. Our obligation under this warranty is limited to repairing or replacing any instrument or part thereof, except tubes, which shall within one year from date of shipment to the original purchaser prove to be defective after our examination.

Instruments to be repaired must be returned to the factory with transportation charges prepaid. Repair work will be performed only upon receipt of a written purchase order or authorization.

Claims for damage in shipment should be filed promptly with the transportation company. All correspondence concerning the instrument should specify the model and serial number. This information appears on the company name plate.

Experienced service personnel and special test equipment are available at the factory to perform any necessary repairs. Every effort will be made to expedite the repair of instruments returned for servicing.

Any inquiry concerning details of operation, possible modifications, etc., should be addressed to the Sales Department, BERKELEY division of Beckman Instruments, Inc., Richmond 4, California.